SOFTWARE VALIDATION TEST PLAN AND TEST RESULTS FOR PROSHAKE, VERSION 1.12

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November 2005

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11-08-2005
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1 SCOPE OF VALIDATION

The software ProShake Version 1.12 was developed by EduPro Civil Systems, Inc (2003). The program computes the response of a semi-infinite horizontally layered soil deposit overlying a uniform half-space subjected to vertically propagating shear waves (Idriss and Sun, 1992a). An equivalent-linear approach is used to approximate the nonlinear, inelastic response of soil (Idriss and Sun, 1992a). The user must input one or more earthquake time histories as well as specify the density, shear wave velocity and shear modulus and damping of each layer in the soil profile. Shear modulus reduction and damping curves can either be selected from ProShake's built-in modulus models, or they may be user defined. The results of the program's calculations include acceleration, shear stress and shear strain time histories as well as response spectra and transfer functions.

ProShake Version 1.12 is an update of the previously validated (Gonzalez, 2005) version of ProShake (Version 1.11). The difference between these versions is documented on the ProShake website (http://www.proshake.com/). The ProShake website notes that a new feature was added to analyze multiple input data files, in sequence, in the "Solution Manager." However, this feature was already available in Version 1.11. However, when validating Version1.11, only a single input time history was used and the feature for analyzing multiple input files was not tested.

This software validation is identical to the validation performed for ProShake Version 1.11 which involved calculating the response of a 49.5 [150-feet] thick soil profile consisting of clay and sand overlying a halfspace. The input time history was the Diamond Heights (EW component) recording of the 1989 Loma Prieta earthquake. The results obtained from Version 1.11 will be compared to the results obtained using Version 1.12. In addition, the feature of analyzing multiple data files in Version 1.12 will be tested by performing the calculations using the Diamond Heights, Treasure Island and Yerba Buena Island recordings of the 1989 Loma Prieta earthquake and comparing the results with those obtained from the program SHAKE91 (Idriss and Sun, 1992b). SHAKE91 is a widely used ground response analysis program and is identical to ProShake in that is uses an equivalent-linear approach. In performing the above calculations, the full capabilities of ProShake are tested.

2 REFERENCES

EduPro Civil Systems, Inc. "ProShake. Version 1.12." Sammamish, Washington. 2003.

Gonzalez, S. "Software Validation Test Plan and Test Results: ProShake, Version 1.11." San Antonio, Texas: CNWRA. 2005.

Idriss, I.M and J.I. Sun. "SHAKE91." Center for Geotechnical Modeling. Department of Civil & Environmental Engineering. University of California, Davis. 1992a.

Idriss, I.M. and J.I. Sun. "User's Manual For Shake91: A Computer Program for Conducting Equivalent Linear Seismic Response Analyses of Horizontally Layered Soil Deposits." Center for Geotechnical Modeling, Department of Civil and Environmental Engineering. Davis, California: University of California. 1992b.

National Information Service for Earthquake Engineering (NISEE) website
http://nisee.berkeley.edu/software/shake91/

3 ENVIRONMENT

3.1 Software

ProShake was built to operate within the MS Windows™ family of operating systems. Specifically Windows 95, NT 4.0 or higher.

3.2 Hardware

The following is a list of minimum requirements needed to run the application:

- IBM PC-compatible 486 or better
- A VGA or higher monitor is required

4 PREREQUISITES

Not applicable.

5 ASSUMPTIONS AND CONSTRAINTS

None.

6 TEST CASES

6.1 Ground Response Calculation

6.1.1 Objective

Demonstrate that ProShake can correctly calculate the seismic ground response at a specified site as well as successfully analyze multiple input data files, in sequence, in the "Solution Manager."

6.1.2 Test Input

A ground response calculation will be performed for a 49.5 m [150-ft] soil profile consisting of clay and sand over a half-space. The relevant properties of this soil profile are provided in Table 6-1. The response will be calculated using the earthquake time history which was recorded at Diamond Heights from the 1989 Loma Prieta earthquake. Shear modulus reduction and damping curves will be selected from ProShake's built-in models. The results from this validation will then be compared to those from the ProShake Version 1.11 validation. The same ProShake input file "SHAKE.DAT" and corresponding input time history "DIAM.EQ" used to validate Version 1.11 will also be used in this validation and are available electronically on the attached CD.

Table 6-1. Profile Inputs

Layer Number	Material	Thickness (ft)	Tot. Press. (ksf)	Modulus (ksf)	Damping	Unit Wt. (kcf)	Shear Vel. (fps)
1	Sand	5	0.31	3882	0.05	0.125	1000.0
2	Sand	5	0.78	3144	0.05	0.125	900.0
3	Sand	10	1.25	3144	0.05	0.125	900.0
4	Sand	10	1.88	3503	0.05	0.125	950.0
5	Clay	10	2.5	3882	0.05	0.125	1000.0
6	Clay	10	3.13	3882	0.05	0.125	1000.0
7	Clay	10	3.75	4697	0.05	0.125	1100.0
8	Clay	10	4.38	4697	0.05	0.125	1100.0
9	Sand	10	5.03	6823	0.05	0.130	1300.0
10	Sand	10	5.71	6823	0.05	0.130	1300.0
11	Sand	10	6.38	7913	0.05	0.130	1400.0
12	Sand	10	7.06	7913	0.05	0.130	1400.0
13	Sand	10	7.74	9084	0.05	0.130	1500.0
14	Sand	10	8.41	9084	0.05	0.130	1500.0
15	Sand	10	9.09	10335	0.05	0.130	1600.0
16	Sand	10	9.76	13081	0.05	0.130	1800.0
17	Rock	—	—	69565	0.01	0.140	4000.0

An additional ground response calculation will be performed using the "SHAKE.DAT" and "DIAM.EQ" input files, as above, along with the two other earthquake time histories recorded from the 1989 Loma Prieta earthquake: Treasure Island "TREAS.EQ" and Yerba Buena "YERBA.EQ". These time histories were obtained from the ProShake program directory (c:\Programs\ProShake-1.12) and are also available electronically on the attached CD.

The relevant files needed to run Shake91 were downloaded from the National Information Service for Earthquake Engineering (NISEE) website: http://nisee.berkeley.edu/software/shake91/. These files are available on the attached CD and include "INP.DAT," "Shake91.exe," and the directory "SOURCE." The "SOURCE" directory contains the files: "A1.FOR," "B1.FOR," "C1.FOR," and "MAIN.FOR."

6.1.3 Test Procedure

(1) Start the ProShake program and from toolbar menu select "Input Manager." A new window will appear. From the toolbar menu select "File" then "New." Open the input file used in the Version 1.11 validation "SHAKE.DAT" and then save with a different name filename (e.g., SHAKE1.DAT) so that the output files will have a different name than the output files generated by Version 1.11. ProShake automatically generates output files with the same name as the input file (but with a different extension). Make sure that the specified location of the input time history (i.e., "DIAM.EQ") is set to the current directory. The current directory should be "test."

(2) Save the input file then click on "Solution Manager" in the toolbar menu. Select the file "SHAKE1.DAT" from the "test" directory to be analyzed.

(3) Click on "Output Manager" in the toolbar menu. A window "Output File Name" will appear. Select the file "SHAKE1.LYR." A new window will appear which displays the various forms of output which may be selected. Click on the "Ground Motion" tab, and check the "Include" box for layer 1. Next check "time history," then "acceleration." Then click on the "Plot" button located at the lower right of the window. An acceleration time history plot will appear. Click on the "Write Data to File" button to save the data. Then click on the "Return" button to return to the previous window. Repeat for response spectrum.

(4) Click on the "Response Spectrum" tab, and check the "Include" box for layer 1. Then click on the "Plot" button located at the lower right of the window. In the plot window click on the "Write Data to File" button to save the data.

(5) Open the "SHAKE1.DAT" file created in Step 1 and then save with a different filename (e.g. SHAKE2.DAT).

(6) Click on the "Input Motion" button in the toolbar menu. A new window will appear (refer to Figure 6-1). Fill in this window as shown in Figure 6-1 selecting the three different input time histories (in order): "DIAM.EQ," "TREAS.EQ," and "YERBA.EQ." Save the input file then click on "Solution Manager" in the toolbar menu and run the analysis.

(7) In the "Output Manager" plot and save the response spectra (as in step 4). There will be one output file containing the results for all three analyses. An example of this output file is shown in Figure 6-2. In Figure 6-2, columns 1, 3, and 5 correspond to period and columns 2, 4, and 6 correspond to spectral acceleration.

(8) Exit ProShake.

(9) In order to perform a comparison calculation in SHAKE91 the SHAKE91 program files from the NISEE website need to be copied into the "test" directory.

(10) Open the "INP.DAT" file and make sure that the input time history file name is "DIAM.EQ." Also make sure that the peak ground acceleration in the input file (the third line beneath the "Option 3–input motion:" line) corresponds to "0.1128945," which is the peak ground acceleration of the "DIAM.EQ" recording. Save this file as "INP1.DAT."

(11) Next click on the file "Shake91.exe" and then type in the relevant file names after each prompt, as shown in Figure 6-3 after each prompt. The two output files (OUT1A.OUT and OUT1B.OUT) contain the results needed make comparisons with ProShake.

(12) Open the "INP.DAT" file and change the input time history file name to "TREAS.EQ." Also change the third line beneath the "Option 3–input motion:" line to 0.1571014 which corresponds to the peak ground acceleration of this recording. Save this file as INP2.DAT and name the two output files "OUT2A.OUT" and "OUT2B.OUT."

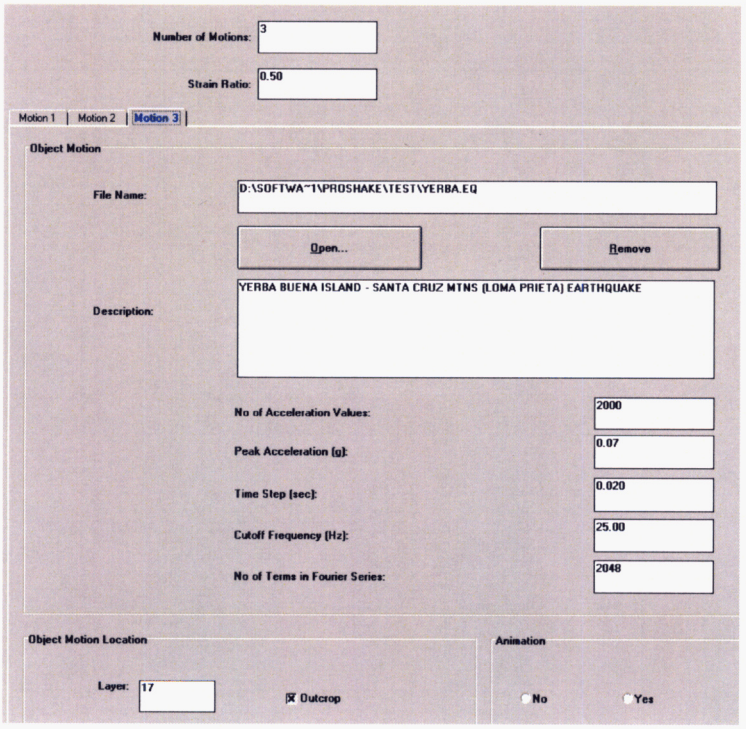

Figure 6-1. Input Motion Window

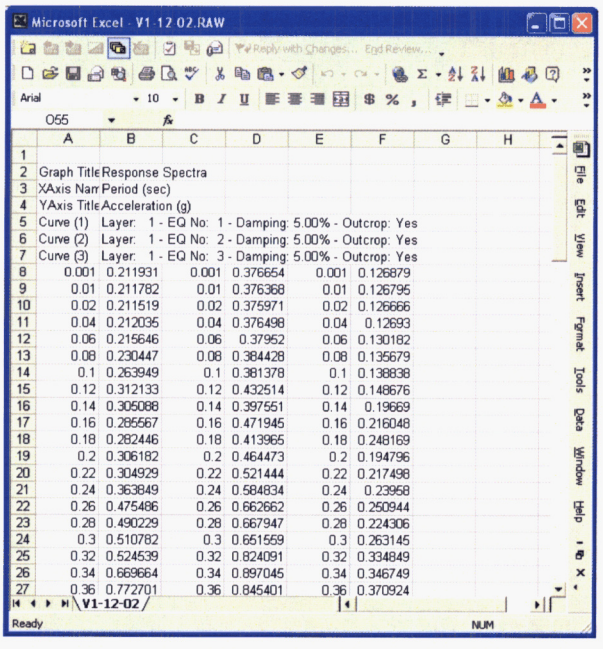

Figure 6-2. Example of ProShake Output File for Response Spectra

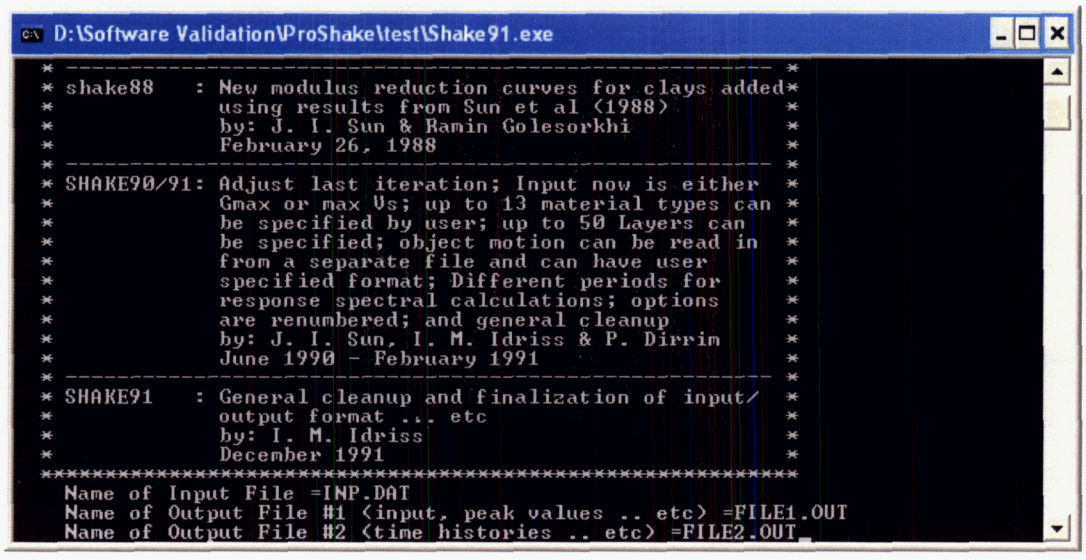

Figure 6-3. SHAKE91 Window

(13) Open the "INP.DAT" file and change the input time history file name to "YERBA.EQ." Also, change the third line beneath the "Option 3–input motion:" line to 0.06505203 which corresponds to the peak ground acceleration of this recording. Save this file as INP3.DAT and name the two output files "OUT3A.OUT" and OUT3B.OUT."

6.1.4 Test Results

A comparison of the respective output time histories at the top of layer 1 for both ProShake version calculations are provided in Figure 6-4. The response spectra (5 percent damped) at the surface of layer 1 is shown in Figure 6-5. Differences between the two sets of plots are less than 0.81 percent. Figures 6-6, 6-7, and 6-8 plot the output response spectra at the surface of layer one for the input time histories "DIAM.EQ," "TREAS.EQ," and "YERBA.EQ," respectively. The similarity between the ProShake Version 1.12 output and the SHAKE91 output demonstrates that the ProShake procedure of analyzing multiple input data files, in sequence, is working correctly.

Based on the above comparisons, and the minor observed differences, this validation test is successful.

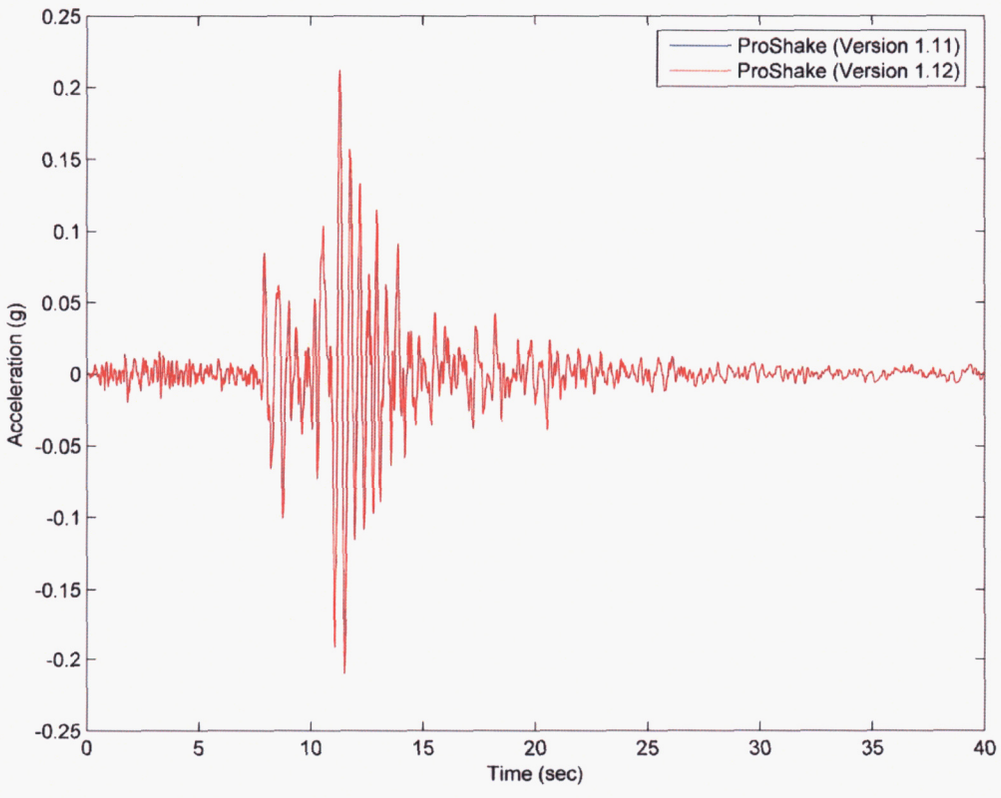

Figure 6-4. Comparison of Response Spectra for Both Versions of ProShake

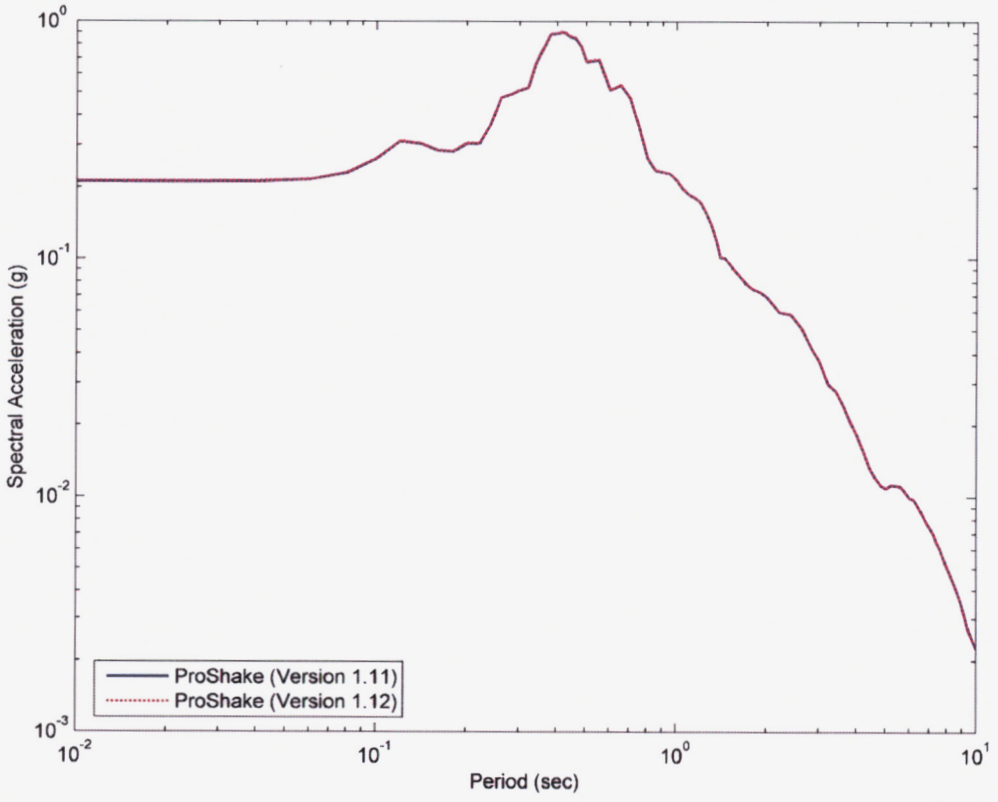

Figure 6-5. Comparison of Output Response Spectra for Both Versions of ProShake

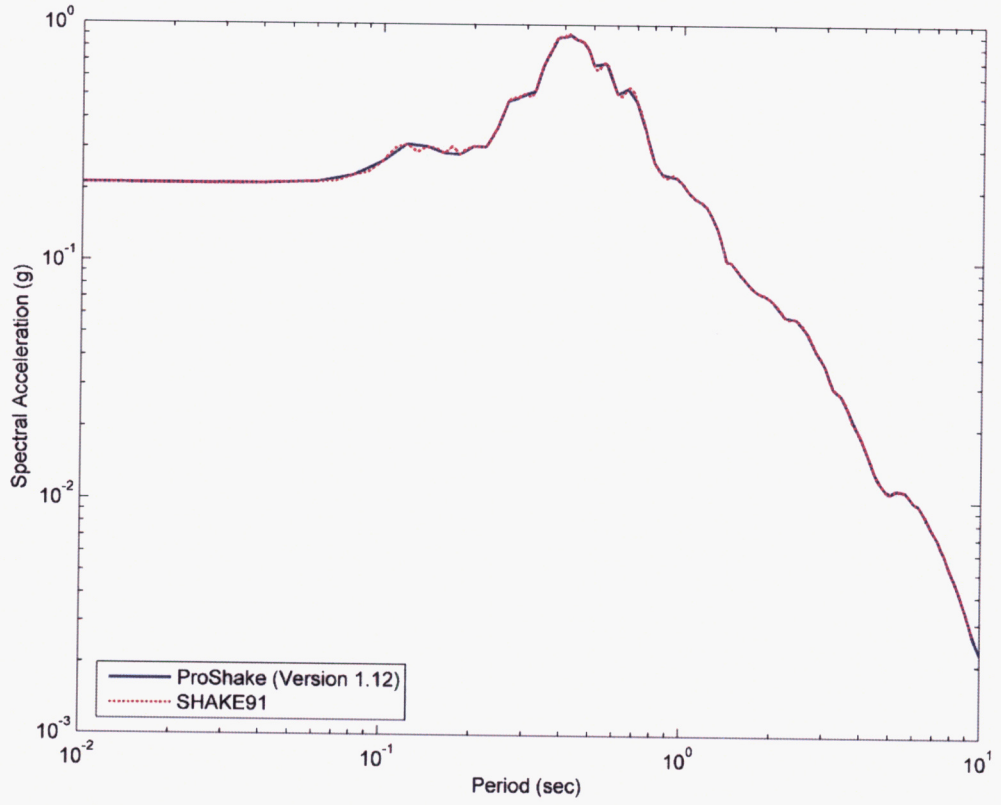

Figure 6-6. Comparison of Output Response Spectra for the "DIAM.EQ" File

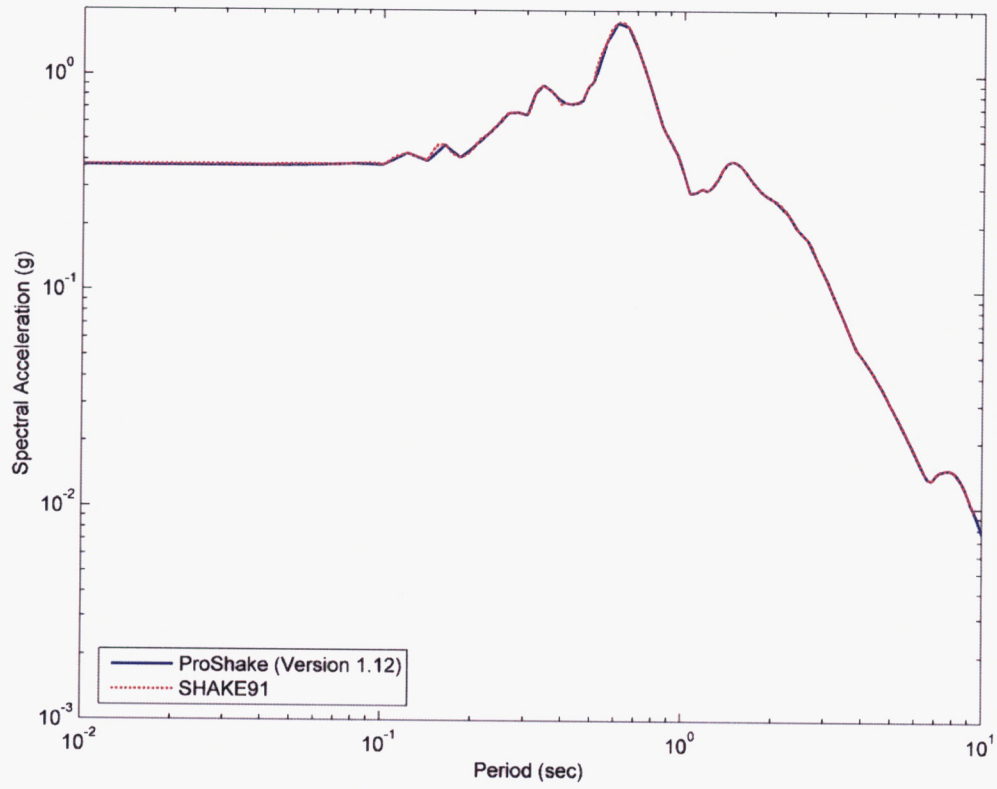

Figure 6-7. Comparison of Output Response Spectra for the "TREAS.EQ" File

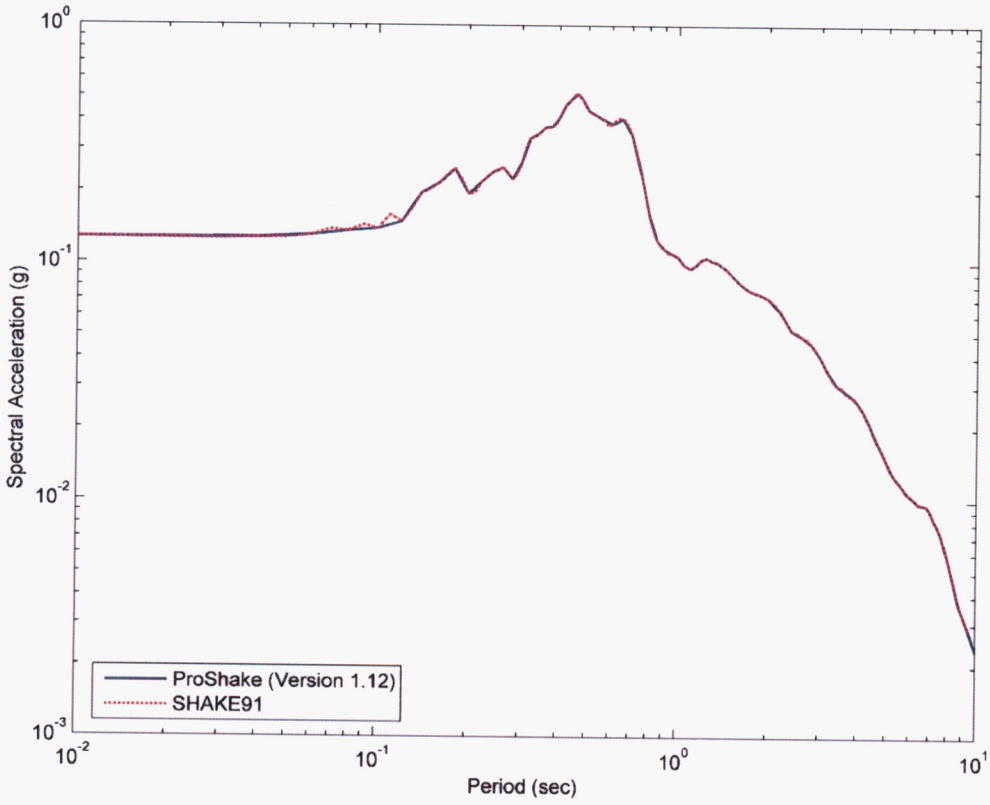

Figure 6-8. Comparison of Output Response Spectra for the "YERBA.EQ" File